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the proximal and middle row of phalanges. One or more, often all of the fingers are involved. The resulting deformity is known in the community as 'stiff fingers,' in contradistinction to the normal which are called 'crooked fingers.' This condition has been transmitted through seven generations, the progenitor of the family having migrated from Scotland to Virginia in 1700. There are connections of the family still in Scotland who carry the trait.

In the Virginia branch, which has been made the object of this statistical study, record has been secured of 312 descendants, among whom there were 84 affected persons, a few more than the 25% of the total number which would be expected. Excluding the incomplete families of the first three generations, in which were recorded few other than the affected persons carrying the trait, there are 72 completed families comprising 302 individuals. Of these 72 completed families, 44 of them were from the mating of unaffected parents with 152 unaffected children. Of the 28 families in which there was an affected parent, there were 150 children, 78 of them, or 52%, carrying the trait. It has been observed that the trait may be transmitted in outspoken form by a parent in whom it is inconspicuous, though never by an unaffected parent. The trait moreover is transmissible by either sex, and both hands and feet of the affected individuals may be involved.

The character, in short, behaves as a simple Mendelian dominant, with equal chance, among the offspring of affected individuals, that it will be or will not be inherited.

This paper will appear in full with photographs and charts in a forthcoming number of *Genetics*.

THE RELATIVE STIMULATING EFFICIENCY OF SPECTRAL COLORS FOR THE LOWER ORGANISMS

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The relation between color and reactions in organisms has for many years been a prominent problem in the study of behavior. The earlier investigators (Bert, Lubbock, Romanes, Graber and others) were interested in this problem largely from the point of view of comparative psychology. Their aim was to ascertain the relation between color-vision in man and in the various animals with the hope of thus elucidating the evolution of psychic phenomena.

Loeb studied the reaction to colors in plants and in animals for the purpose of showing that they are the same in both, hoping thus to demonstrate that there is nothing in the nature of psychic phenomena in animals. Other investigators, e.g.,Engelmann, Wiesner, Strasburger, Verworn, Parker and Blaanw, were interested in the problem more from the point of view of comparative physiology.

I have for some time held the opinion that, aside from the importance of this problem in comparative psychology and physiology, it ought to yield results which would throw light on the nature of the chemical changes in the organisms associated with the reactions to light, especially those associated with changes in the sense of the reactions.

The chief difficulty encountered in the work has been connected with obtaining monochromatic light and measuring it in terms suited for comparison. Thus while a considerable number of organisms, both plants and animals, have been investigated in regard to the relation between wave-length and stimulation, only in a few are the results of such a nature that they can be compared with sufficient accuracy to warrant more than very tentative conclusions. Moreover, in a number of cases, otherwise excellent, only the region in the spectrum of maximum stimulation has been ascertained. In the following observations, to be published in full elsewhere, these difficulties and defects have been to a large extent eliminated.

It is well known that many of the simplest organisms respond very definitely to light. Some orient and travel fairly directly towards the light, others away from the light, while still others go toward it under some conditions and away from it under others.

In a field of light consisting of two horizontal beams crossing at right angles these organisms proceed toward or from a point situated between the two beams. The location of this point depends upon the relative effective illumination received by the organisms from these beams. If it is the same in quality and quantity, so that the stimulation is the same, the point lies approximately half way between them. (Details as to the process of orientation in these organisms may be found in my book *Light and the Behavior of Organisms*, John Wiley & Sons, New York, 1911.) Consequently whenever the organisms proceed toward or from a point thus located, it may be concluded that the stimulating effect of the light in the beams is equal, no matter how the light may differ, either in quantity or in quality. (This is literally true for only a few organisms, but the principle as applied holds for all, as will be demonstrated in the extended paper to follow.) It is, therefore, obvious that if the light in one beam is kept constant in quality, white for example, while that in the other is changed in color the relative stimulating efficiency of the different colors can be ascertained. To do this all that is necessary is to vary the luminous intensity of the white light for each change in the colored light until, in each case, the organisms proceed on the same path. The stimulating effect of the different colors will then be directly proportional to the various luminous intensities of the white light required to make the organisms under each of the different conditions, proceed in the same direction, e.g., if for green it required twice as much light from the white source to make the creatures take a given course as it does for yellow, then the stimulating effect of the green is twice as great as that of the yellow. To ascertain the relative efficiency in terms of wave-lengths and energy it is only necessary to use a spectrum having a known distribution of energy, and to make corrections in accord with this distribution.

In the experiments referred to below, two gas-filled street-series tungsten lamps with coiled filaments were used in series to produce two beams of light. One of these beams passed through a Hilger constant deviation spectrometer and the other through a Lummer-Brodhun rotating sector. The whole apparatus was so arranged that the two beams of light crossed at right angles in the field of observation. For every color tested the intensity of the illumination in the beam of white light was adjusted by varying the opening in the sector, until the course of the organisms bisected the angle between the two beams of light. In nearly all cases the successive regions selected in the spectrum differed by 10 $\mu\mu$. In this way the relative stimulating effect for the different regions of the spectrum was ascertained in fifteen different species as follows: Chlamydomonas, Trachelomonas and Phacus, each one species; Euglena, five species; Panderina, Eudorina, Gonium and Spondylomorum, each one species; earthworms, Arenicola (larvae) and blowfly (larvae) each one species. All but the last three are green, microscopic organisms, relatively very simple in structure.

The results obtained will be stated in terms of relative stimulative effects of the different regions of the spectrum tested without corrections for the difference in the energy of these regions. They are, however, of such a nature that the corrections mentioned will not result in marked alterations. These corrections will appear in the final paper.

For all but one of the microscopic organisms the results fall into two groups. In the one group the region of stimulation begins in the blue near the violet, between 430 and 440 $\mu\mu$. From here toward the red end of the spectrum the stimulating efficiency rises, at first slowly and then rapidly, to a maximum in the green near the yellow, between 530 and 540 $\mu\mu$; then it falls, at first rapidly and later more and more slowly, ending in the red at about 640 $\mu\mu$. In the other group the region of stimulation begins in the violet between 420 and 430 $\mu\mu$, only a short distance from the place where it begins in the first group. From here the efficiency rises very rapidly reaching a maximum in the blue between 480 and 490 $\mu\mu$. It then falls rapidly and ends in the green in the neighborhood of 520 $\mu\mu$. Three of the microscopic forms, Pandorina, Eudorina and Spondylomorum, belong to the first group, the rest to the second. To this group belong also Arenicola larvae and the earthworms. For the remaining microscopic form (Chlamydomonas) the maximum is in the green very near 510 $\mu\mu$; and for the blowfly larvae it is approximately at 520 $\mu\mu$. The distribution in the spectrum, of stimulating efficiency is, for this creature, essentially the same as the distribution of brightness for totally color-blind persons. No difference in the relative effect of the different wave-lengths was discovered in any given species under different conditions. It was the same for organisms collected in different regions at different periods of the day and tested under various conditions of illumination and temperature, and it was the same for negative and positive individuals.

These results show that stimulation in all of the organisms studied depends upon the wave-length of the light; that the stimulating efficiency is very much higher in certain regions of the spectrum than in others; but that the distribution of this in the spectrum differs greatly in certain organisms that are closely related in structure, e.g., Pandorina and Gonium, while it is essentially the same in others that are very different in structure, e.g., Euglena and earthworms. They show, moreover, that if the absorption throughout the spectrum is the same in the different organisms the chemical or physical changes associated with the reactions differ in some species which are closely related. And that the changes in the organism, whatever they may be, which cause changes in the sense of the reactions are not reversible; for if they were reversible one would expect the distribution of stimulating efficiency in the spectrum to differ in positive and negative specimens of the same species.

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